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Diagnosis of the Scientific Literacy Characteristics of Primary Students

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Abstract

This research was to develop a diagnostic test for the scientific literacy characteristic of primary students. The sample group was 30 grade 6 students in the first semester of 2012. The tool was the diagnostic test for scientific literacy characteristics developed from an application of science assessments in PISA, and consisting of 3 factors; knowledge, context and attitude. The diagnosis test coonsisted of multiple choice, data analysis by difficulty, discrimination, reliability and construct validity by confirmatory factor analysis. The result of the research revealed that the diagnostic test was able to assess scientific literacy well, the model was according to the empirical data. It has been identified that the sample group had a misconception of scientific literacy characteristics in terms of knowledge and context.

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Keywords: scientific literacy, diagnosis, PISA

1. Introduction

Science is a key aspect of culture in the modern knowledge-based society. Therefore, many countries have prioritized the development of cognitive science for their people. Science plays a very important role in present and future society in that it is associated with everyone in their everyday life and work, including technologies, equipment, and products that are being used to facilitate human life and work. All these are the result of the range of sciences in combination with creativity and other disciplines. Science helps humans to develop the ways of thinking, to be reasonable, creative, analytical, critical, develops essential skills in knowledge research, the ability to resolve problems systematically, and to make decisions using a variety of information in the form of verifiable evidence (Ministry of Education, 2008). International education today is therefore focusing on the importance of literacy as stated in the goals of the EFA (Education For All) as designated by UNESCO. UNESCO believes that literate people will reduce various problems and will lead to sustainable development. Additionally, the dynamic change in today's society requires a link between essential competencies and the complexity of living. The enGauge 21st

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Century Skills for 21st Century Learners represents the important factors of digital-age literacy which scientific literacy as one of the eight important topics of literacy for students (NCREL, 2003).

A group of developed country that expressed interest in the development of their citizenship to cope with such circumstances is the OECD (Organization for Economic Co-operation and Development). There has been a study of the effectiveness of the educational systems of the member countries, and the results provided feedback as to whether or not their education system was sufficient to prepare students to thrive in the future (OECD, 2003). OECD has been researching this topic over the past ten years, and has developed an important assessment program called "Program for International Student Assessment (PISA)" aimed at evaluating the readiness of education systems for students such as to allow them to thrive and participate in future society. Scientific literacy is one of the important areas of assessment together with reading and mathematics (The Institute for the Promotion of Teaching Science and Technology, 2006). Thailand has been participating the PISA Plus program since 2000 together with another 65 participating countries. However, the assessment in 2009 showed that 15-year Thai students have an average score in scientific literacy of 47 – 49 which was lower than the OECD average which means that it is lower than the standard (The Institute for the Promotion of Teaching Science and Technology, 2011).

The PISA results reflect the situation that science education in Thailand was not sufficient when it comes to preparing students for being competitive with learners in other countries. Therefore, the education reform of the second decade (2009 – 2018) has set strategic goals to improve the quality of people and education in Thailand to meet international standards. The achievement aims to raise mathematics and science education to at least the international average according to PISA (Office of the Education Council, 2012). Therefore, the development of scientific literacy for students needs to be fostered from the primary level to establish the foundation for students to be able to develop competency in higher education. In order for teachers to develop learners more effectively, they should understand basic information about the students in their classrooms, and also able to diagnose students individually. Such diagnosis will involve assessment to provide students' learning information in relation to their attainment in specified knowledge and skills, or students' misunderstanding of the concepts or contents offered by teachers. Such information can then be used by the teachers to improve their teaching. Therefore the development of diagnosis skills is imperative as a tool to help teachers to identify mistakes, weaknesses, and area for improvement on the part of the learners both academically and psychologically (Sucheewa, 2007). In this research, the researchers have therefore studied the scientific assessment used by PISA and applied it as a framework to develop the diagnostic test for the scientific literacy characteristics of primary students. The assessment results will provide teachers with the information and the characteristics of scientific literacy of students in the classroom, in order to plan and design appropriate teaching and learning in accordance with the learners' abilities and characteristics.

2. Objectives of research

To develop and examine the quality of a diagnostic test for the scientific literacy characteristics of primary students.

3. Definitions used in this research

The aim of this diagnostic test for the development of the scientific literacy characteristics of primary students was to develop and examine the assessment tool in terms of the scientific literacy characteristics of grade 6 primary students according to 3 factors following the framework of scientific assessment developed by PISA (2009), as shown in Table 1

As the diagnosis test for scientific literacy was developed for grade 6 primary students, the researchers have studied additional documents to define the questions in accordance with the framework of scientific assessment published by PISA (2009). By studying the quality in science substances students who had completed the second level (grades 4 - 6) according to the Basic Education Core Curriculum B.E. 2551 and science textbooks for grades 4 to 6, the choice of the questions was relatively simple according to the principles of diagnostic test design (National Institute of Educational Testing Service, 1996). Furthermore, the researchers aim to develop this tool to evaluate students, to allow teachers to understand the basic scientific literacy characteristics of their students in the classroom, and to be able to use the information promptly. Therefore, the number of questions for each factor in the diagnostic test was not as many as suggested by the principles of diagnosis test design.

Table 1. Factors in the diagnosis test for scientific literacy

Key factors	Definition of factors
1. Knowledge	- Scientific knowledge: Knowledge of the natural world - Scientific related knowledge: Knowledge related to the scientific knowledge
2. Context	- Acknowledgement of the circumstances in life related to science and technology in; health, natural resources, environmental quality, and the danger and harm and scope of science and technology
3. Attitude	- Demonstrate responsiveness in science with interest - Promote investigation in scientific knowledge - Demonstrate responsibility for scientific-related issues

4. Research Methodology

The population in this research was primary students in grade 6. The sample group was 30 students chosen by simple random method. The research tool was the diagnosis test for scientific literacy with 3-multiple choice questions. The researchers developed the diagnostic test mainly according to the framework of scientific assessment of PISA (2009). This consisted of 3 factors; knowledge, attitude, and context. Each factor consisted of 5 questions, making a total of 15 questions in the diagnosis test.

5. Findings

5.1 The results in terms of reliability, difficulty, and the discrimination of the tools

The analysis of the diagnosis test for the scientific literacy characteristics of primary students, according to the factors of knowledge, context and attitude were shown by the Cronbach's Alpha-coefficients to be .506 .614 and .325 respectively. The test for each factor was relatively simple and the researchers were able to classify the respondents on a range from moderately to very good. The knowledge factor had a difficulty index between .67 - .93 and a discrimination index between .40 - .47; the context factor had a difficulty index between .70 - .93 and a discrimination index between .25 - .47; the attitude factor had a difficulty index between .57 - .87 and a discrimination index between .27 - .60, as shown in Table 2.

Table 2. Difficulty and discrimination index of the diagnosis test for scientific literacy characteristic analyzed by each question of each factor

Factors	Questions	Difficulty index	Discrimination index

1. Knowledge (KA)	K1	.93	.26
	K2	.67	.40
	K3	.60	.25
	K4	.77	.47
2. Context (CA)	K5	.65	.30
	C1	.57	.25
	C2	.90	.26
	C3	.58	.30
	C4	.70	.47
3. Attitude (AA)	C5	.93	.28
	A1	.87	.27
	A2	.83	.33
	A3	.57	.47
	A4	.63	.60
	A5	.93	.25

5.2 Results in terms of the construct validity of the tools

The results in terms of the construct validity of the tools using confirmatory factor analysis showed that the diagnosis test for scientific literacy for primary students had good construct validity as shown in Figure 1.

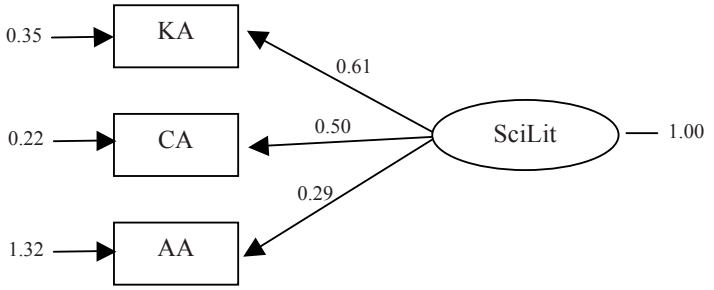

Figure 1. Construct validity of the diagnosis test for scientific literacy

5.3 Results in terms of the scientific literacy characteristics of the sample group

The assessment of the scientific literacy characteristics of 30 grade 6 students demonstrated that the overall score in terms of scientific literacy in each factor was of a moderate-good standard. However, the analysis of scores in each factor revealed that the context factor, as with the knowledge factor, had the lowest average score and were of a moderate standard, while the attitude factor had the highest average score and was of a good standard, as shown in Table 3.

Table 3. Arithmetic average, standard deviation and students' scientific literacy standard

Scientific Literacy Factors	$\bar{X}$	S.D.	Standard
1. Knowledge	2.80	1.03	Moderate
2. Context	2.77	0.68	Moderate
3. Attitude	3.83	1.26	Good
Total	3.13	0.90	Moderate

6. Summary and discussion

The objective of this research with regard to the diagnosis of the scientific literacy of primary students was to develop and examine the quality of the diagnostic test for scientific literacy characteristics. The test was developed

according to the framework of scientific assessment produced by PISA (2009), and consisted of 3 scientific literacy factors; knowledge, context and attitude. The diagnostic test contained 15 questions in total. The quality of the diagnostic test was good in terms of reliability, difficulty, discrimination, and construct validity. The assessment of scientific literacy of the sample group demonstrated an overall moderate standard. The attitude factor had better average scores than the knowledge and context factors. The research findings reflected that the teaching and learning of science subject with regard to primary students was not sufficiently focused on foundations, and did not promote scientific literacy according to the PISA framework. These findings may be of significance in relation to the relatively low standards of 15-year-old Thai students in the PISA scientific literacy assessment. Therefore, the preparation with regard to scientific literacy in primary education should receive more collaborative attention on the part of teachers and school principals to drive and promote such an aim, by using the findings from the diagnosis test. The methodology to promote learning activities for primary students in Thailand to increase their scientific literacy competency, is still limited, in that the only research undertaken was that done by Marakrong (2010), which was a scientific literacy model in accordance with the STS Approach for grade 6 students. Most of the research in scientific literacy development has focused on lower secondary level students.

Another interesting finding that the researchers recognized from the diagnosis test assessment was that the factored questions provided interesting information that the teaching and learning approaches used by science teachers could build positive attitudes in group activities. More than 80% of the students enjoyed group activities compared with than individual activities, thought of applying scientific knowledge to everyday life, and appreciated scientists and their creations which are beneficial to human beings. Nevertheless, the findings also revealed that the moderate standard of scientific literacy in terms of knowledge and context factors may be a result of students' misconception with regard to the two factors. For example, one of the context statements was: "classroom is a higher pressure area than the peak area" , In answering this, 80 percent of the students disagreed with the statement even though it was true. Despite other true knowledge statements: "railroad tracks require to adhere to the principle that solids expand when heated and shrink when cooled" and "the earth takes 1 day to go around its axis, while the moon takes 1 month to rotate around the earth", more than 75 percent of the sample group disagreed or were uncertain (more uncertain than disagreed). This finding indicates that teachers need to pay more attention to teaching and learning that focuses on the right concepts for students, strengthens confidence, and increases the link between the environmental context in which the students live and teaching and learning. Misconception is a key issue that teachers need to pay attention to and take emerging corrective actions in such a way as to prevent the link between students' misconceptions and other related areas of learning. Therefore, the information from the diagnosis of scientific literacy will enable teachers to view students' defects clearly. Teachers should continuously diagnose students by using both formative assessment and summative assessment. This will enable teachers to monitor the change in students' conceptions after teaching and learning has been reformed, and to improve the students' conceptions.

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